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May 1949

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MINING METHODS AND COSTS AT THE ATWOOD COPPER MINE LORDSBURG MINING DISTRICT, HIDALGO COUNTY, N. MEX.

BY

WALTER R. STORMS

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MINING METHODS AND COSTS AT THE ATWOOD COPPER MINE, LORDSBURG MINING DISTRICT, HIDALGO COUNTY, N. MEX.[1]

By Walter R Storms[2]

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[1] Manuscript completed February 2, 1948. The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is made: "Reprinted from Bureau of Mines Information Circular 7502."

[2] Senior mining engineer, Bureau of Mines.

INTRODUCTION AND SUMMARY

This paper, which describes the mining methods and costs at the Atwood copper mine in the Lordsburg (Virginia) Mining District of Hidalgo County, N. Mex., is one of a series being prepared by the Mining Division of the Bureau of Mines on mining practices, methods, and costs in various mining districts of the United States.

The mine and surface plant are situated in the west half of sec. 7, T. 23 S., R. 18 W., about 3 miles by road southwest of the center of Lordsburg, near the old abandoned townsite of Valedon (see fig. 1). The main line of the Southern Pacific Railroad passes through Lordsburg, as does the paved east-west U. S. Highway 70-80. A spur line of the Southern Pacific ends near the mine. A good graded road connects the mine with Lordsburg.

The following pages present a brief history of the district, describe the geology; and outline methods of prospecting and exploration, including sampling and estimations of tonnages and values. Development and mining methods are explained; and transportation, ventilation, drainage, safety measures, and organization are described. The wage scale and costs of development and mining comprise the concluding sections of this circular.

ACKNOWLEDGMENTS

Acknowledgment is made to the operator of the Atwood mine, C. H. McIntosh of Los Angeles, Calif., for permission to publish this paper. Special acknowledgment is due William S. Harrison, superintendent at the Atwood, for his valuable assistance; to J. H. Hedges, chief of the Tucson Branch, Mining Division, Bureau of Mines, for his suggestions and help; and to Morgan G. Huntington, formerly a mining engineer with the Bureau of Mines, for much of the data on History and Geology and for figures 1, 2, and 3.[3]

HISTORY

Mining actually began in the Lordsburg district in 1870, when some attempts were made to ship silver ore, but the first real activity did not begin until the Southern Pacific Railroad was built through Lordsburg in 1880. Silver mining was the principal activity until the price of that metal fell to 78 cents, in 1893. Later, in 1899, the district became a copper-mining area when the price of copper rose to 17 cents.

The total ore produced from the district prior to 1904 is estimated at 50,000 tons. From 1904 through 1935, production was about 1,595,500 tons containing 2.58 percent copper, 0.117 ounce of gold, and 2.24 ounces of silver a ton. Ninety percent of this production came from the old Eighty-five mine, which was closed in January 1932.

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[3] Huntington, Morgan G., Atwood Copper Group, Lordsburg District, Hidalgo County, N. Mex.; Bureau of Mines Report of Investigations 4029, March 1947, 9 pp. The historical and geological sections of that report were based in part on Lasky, S. G., Geology and ore deposits of the Lordsburg mining district, New Mexico: U. S. Geol. Survey Bull. 885, 1938.

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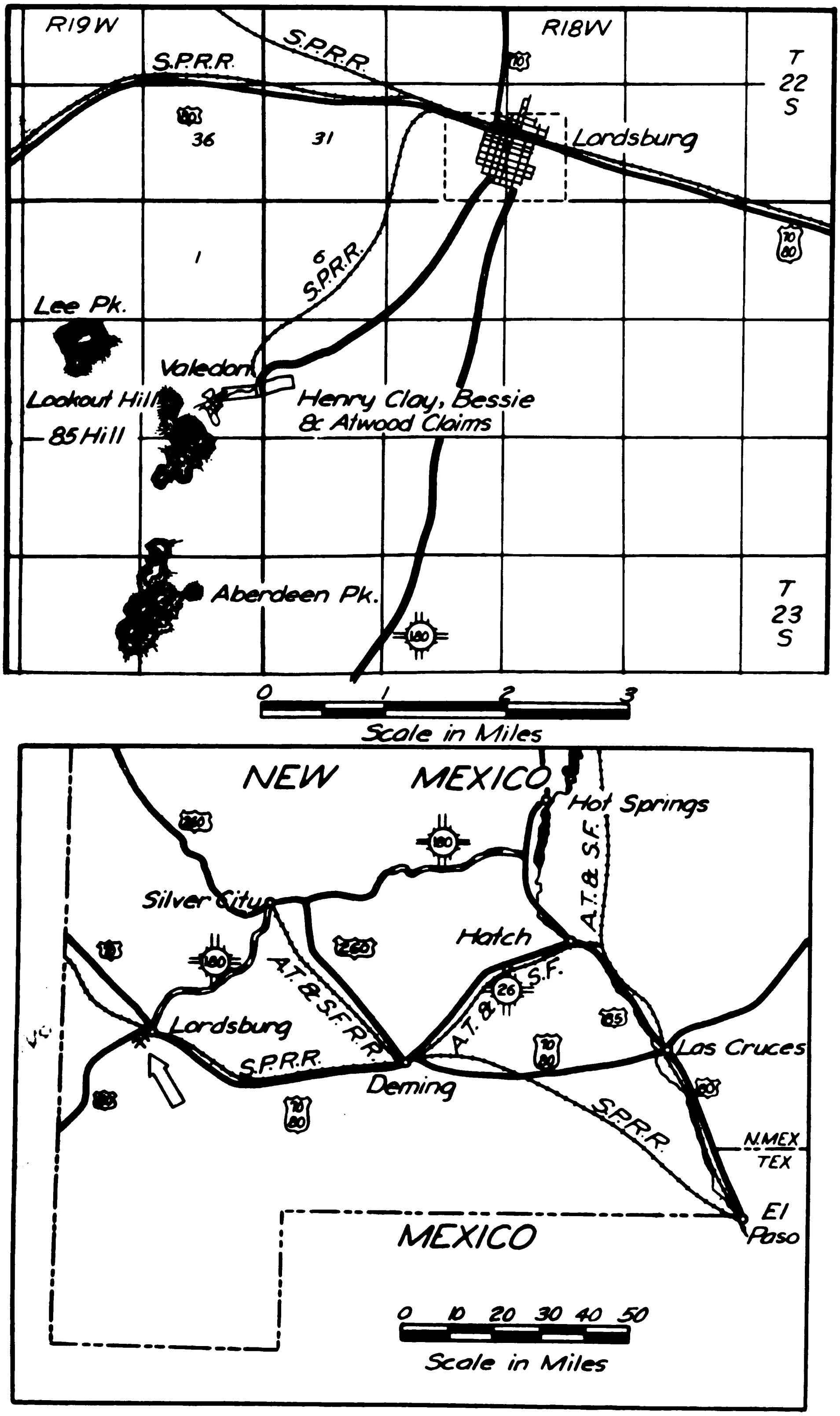

Figure 1. - Location map.

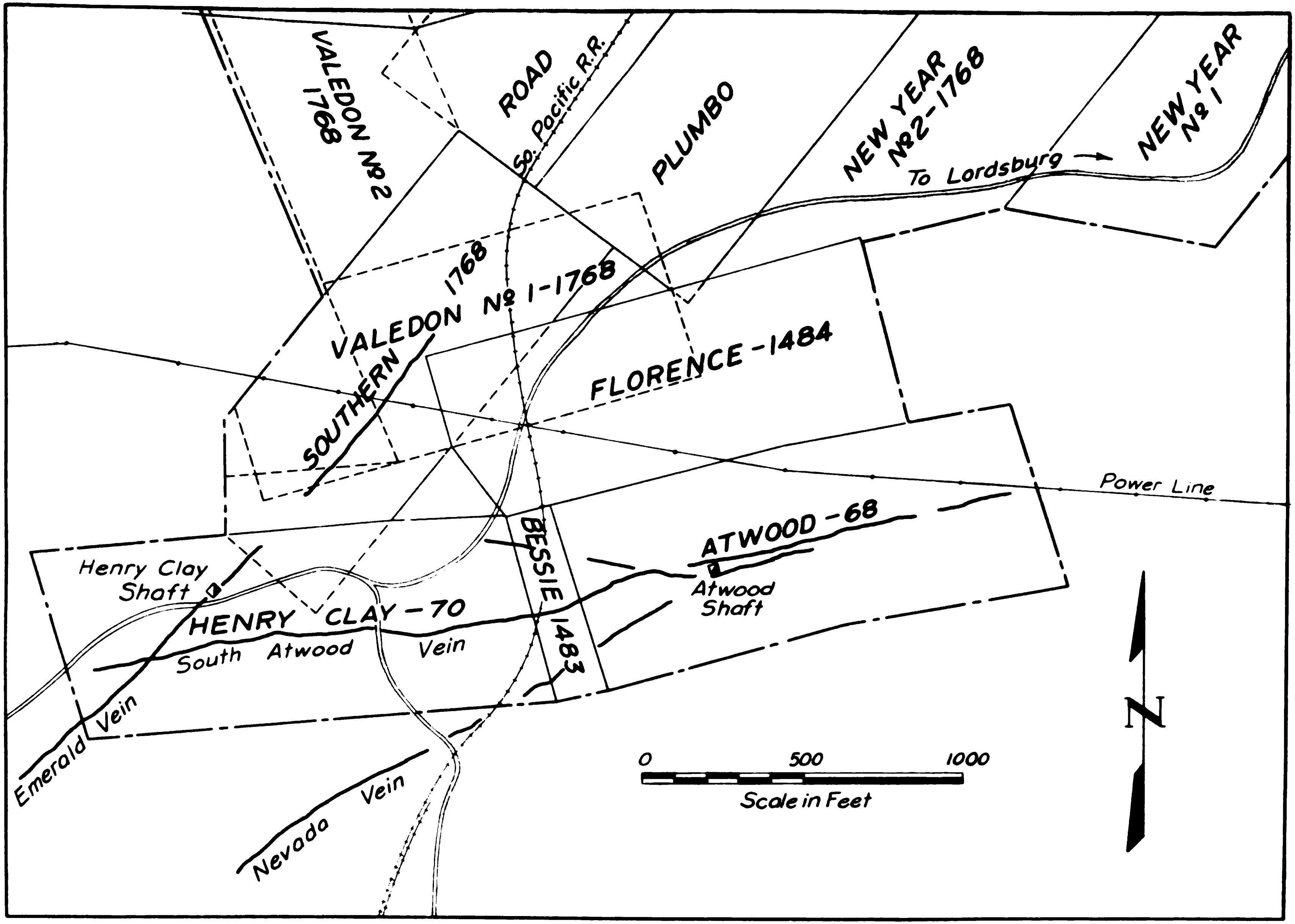

Figure 2. - Claim map, Atwood-Henry Clay group.

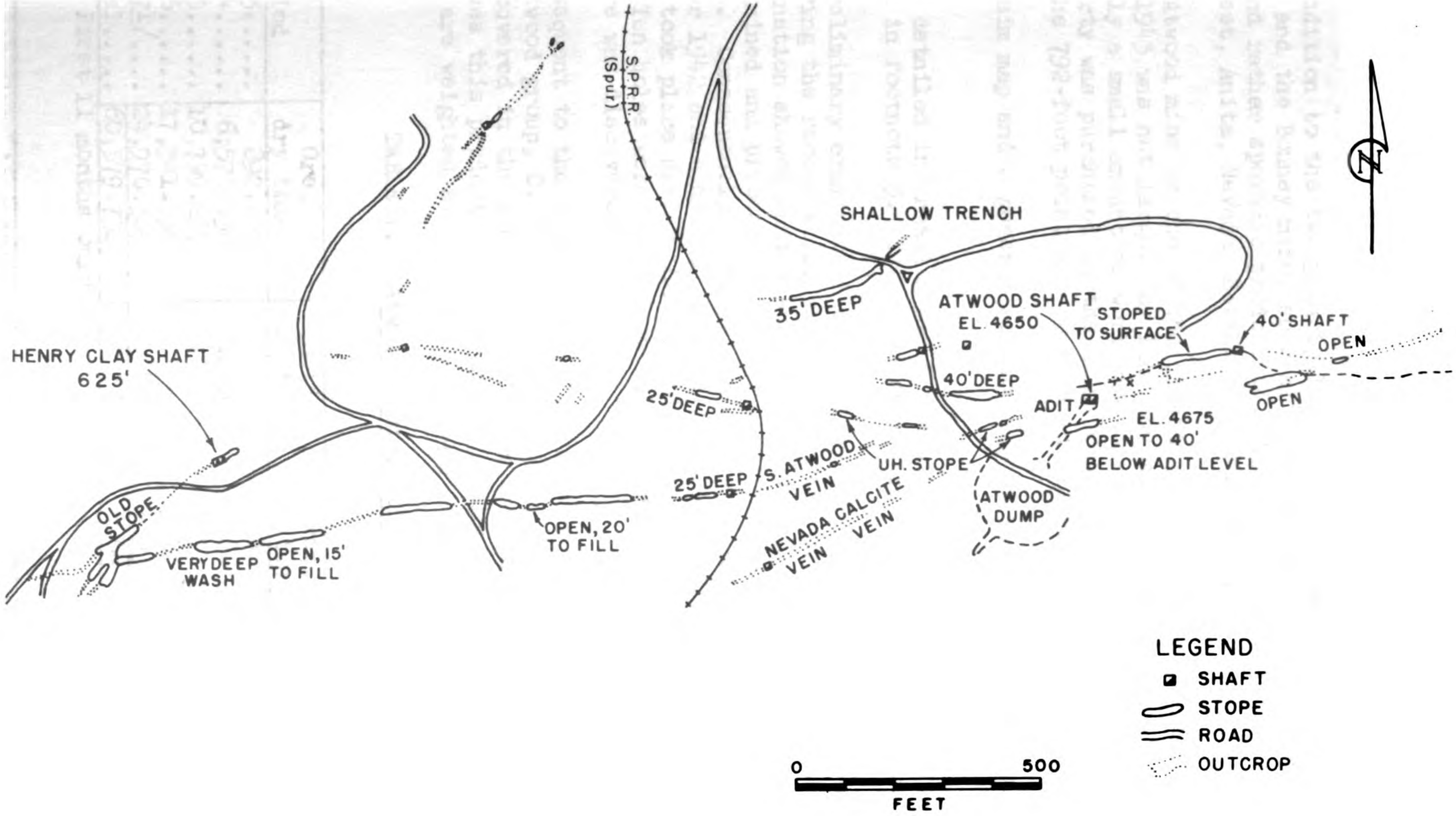

Figure 3. - General surface map, Atwood-Henry Clay area.

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In June 1935, the Bonney mine in the Lordsburg district was purchased by the Banner Mining Co. This company erected a flotation plant and began milling copper ore from the Bonney in August 1936.

In addition to the two principal producers in the district, the Eighty-five mine and the Bonney mine, several other claims and claim groups have had a small and rather sporadic production. These include the Atwood, Henry Clay, Misers Chest, Anita, Nevada, Battleship, and Ruth groups.

The Atwood mine is one of the oldest in the district, although production prior to 1943 was not large. By 1882 the mine was developed to a depth of 220 feet. Only a small amount of work was done between that date and 1930, when the property was purchased by the Alamo Copper Co. This company developed the mine to the 792-foot point and terminated all work in 1931.

A claim map and a general surface map of the Atwood are shown in figures 2 and 3.

More detailed information about the history is available in the reference mentioned in footnote 3. The above data were obtained chiefly from that source.

A preliminary examination of the Lordsburg mining district was made in 1942, during the recent World War, by a Bureau of Mines engineer, C. H. Johnson. The examination showed that a substantial tonnage of siliceous copper ore that could be mined and processed might be developed with a minimum of capital expenditure. Consequently, exploration of the district by the Bureau was begun in October 1942 and completed in June 1943. Core drilling, trenching, and sampling took place during that period, principally on the Atwood group of claims. Ten holes were drilled on the Atwood claims, and a substantial amount of new ore was discovered.[4]

Subsequent to the completion of the Bureau of Mines field work, the lessee of the Atwood group, C. H. McIntosh, drove a crosscut to a copper-lead-zinc vein discovered in the course of that work and began production. The following table gives this production up to and including the first 11 months of 1947. All analyses are weighted averages from monthly production figures.

TABLE 1. - Atwood production, 1943-1947

Period	Ore, dry tons	Gold, oz./ton	Silver, oz./ton	Copper, percent	Lead, percent
1943......	892.295	0.151	11.40	3.57	2.86
1944......	6,575.930	.148	8.80	2.38	2.10
1945......	10,799.267	.080	5.72	2.30	1.38
1946......	17,341.930	.074	5.12	2.33	1.14
1947[1]....	24,970.309	.058	4.93	2.18	.67
Total.....	60,579.731	.058	5.64	2.29	1.12

[1] First 11 months only.

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[4] For a complete description of this work, see Report of Investigations 4029, previously mentioned in footnote 3.

GEOLOGY

Huntington[5] describes the geology as follows:

> The exposed rocks of the Lordsburg mining district consist chiefly of basalt and rhyolite flows, plugs, and associated fragmental material belonging to two groups of different age and character. An irregular stock of porphyritic granodiorite intrudes the rocks of the earlier group, and both the stock and earlier rocks are cut by several varieties of dikes that are separated from the later volcanic rocks by a later unconformity. Magdalena (Pennsylvanian) limestone crops out at several places in the deeply eroded parts of the range south of the district.
>
> The ore deposits of the Lordsburg district are siliceous veins in fault fissures and shear zones concentrated in and around the northern and eastern margins of the granodiorite stock. There are two main groups of these veins, one striking northeast and the other almost due east. In general, the veins dip almost vertically.
>
> Granodiorite and basalt appear to have been almost equally favorable host rocks. The Eighty-five mine ore shoots were chiefly within or in contact with granodiorite. The Bonney, Henry Clay, Atwood, and numerous less productive veins were in basalt.
>
> Oxidation and secondary enrichment have affected the ores to extremely variable depths. In places, almost unaltered sulfides are found at the surface, yet oxidation and leaching extended to the 1,400-foot level in some places in the Eighty-five mine.
>
> The two principal producers in the district, the Eighty-five and Bonney mines, are on northeast-southwest veins. The Eighty-five mine has exploited the Emerald vein for a continuous distance of about 2,000 feet along the strike and for a vertical depth of 1,900 feet. The Bonney vein has been developed by the Banner Mining Co. to a vertical depth of 1,450 feet and for 2,000 feet along the strike. The minimum stoping width is 4 feet. The maximum vein width in the Banner mine is about 20 feet.

Bureau of Mines drilling indicated a third important deposit on the Atwood claim. The South Atwood vein, which outcrops 50 feet south of the collar of the 750-foot Atwood[6] shaft, strikes N. 80° E. and dips 70° south. This vein had not been explored at depth from the Atwood shaft. Diamond drilling indicated, but did not delimit, a commercial ore body at least 500 feet in length, 250 feet on the dip, and 7 feet in width. Both walls are basalt; however, the basalt is in contact with intrusive breccia 10 to 100 feet north and in the footwall of the vein. It appears that where the vein goes into the breccia, as it does to the east, it becomes almost indistinguishable and is poorly mineralized.

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[5] Huntington, Morgan G., see footnote 3.

[6] The Atwood shaft, sometimes called the Cosden, now is reported to be 792 feet deep.

The Henry Clay workings explore the northeast extension of the Emerald vein for a strike length of 600 feet and for a depth of 600 feet. Both walls of the vein are basalt. The Henry Clay shaft is about 200 feet northeast of the intersection of the Emerald and South Atwood veins.

The vein walls are strong enough to permit shrinkage stoping. The ore removed contains about 20 percent fault gouge and wall rock.

The ore minerals are chalcopyrite with small amounts of sphalerite and galena. Specularite and pyrite also occur. In zones of supergene enrichment, chalcocite occurs as crusts on chalcopyrite. Sphalerite and galena occur in minor amounts in the upper levels of the Banner mine but are practically nonexistent in the lower sections. Specularite is abundant in some stopes. The gangue is chiefly quartz and silicified wallrock with some calcite and minor amounts of tourmaline and barite. The silica content of the Banner ores has decreased from probably 65 percent in the upper levels to 43 percent in the lower. Presumably, the ore from the Eighty-five mine carried more than 65 percent silica, because virtually all of it was sent to copper smelters as siliceous flux.

The ore minerals at the Atwood mine consist principally of chalcopyrite with small amounts of galena and sphalerite. However, the vein is oxidized very irregularly, so that malachite is found even on the 500-foot level. Chalcocite is scarce. Gangue is chiefly quartz and silicified basalt. Ore as sent to the smelter averages about 70 percent silica.

METHODS OF PROSPECTING AND EXPLORATION

As mentioned in a previous section, the Bureau of Mines conducted exploratory work at the Atwood property from October 1942 until June 1943. This work consisted of trenching, test pitting, sampling vein outcrops, and surface diamond drilling at the Atwood and Henry Clay mines, and also shaft rehabilitation, unwatering, crosscutting, drifting, and underground sampling at the Henry Clay alone.

The major work consisted of core-drilling 10 holes totaling 5,310 linear feet. Most of the footage was drilled with a standard AX bit, with a core recovery of 88.5 percent in the veins. Trenching and test pitting were employed chiefly to guide diamond drilling. Most of this work involved only the removal of overburden by hand, and only a small amount of rock in place was excavated. Channel samples were cut where feasible, and in a few instances chip samples were taken. The channels were cut 2 inches deep and 6 inches wide, and the entire sample was sent for analysis without splitting.

Since the Bureau of Mines completed its exploratory work in 1943, work at the property has consisted of crosscutting to the South Atwood vein and drifting along this vein on the 350-, 500-, and 625-foot levels to delimit the ore shoot that was discovered by prior diamond drilling, and diamond drilling on the 500-foot level. Numerous large cross faults were discovered after drifting along

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the vein had been started on the 350- and 500-foot levels. As relatively little was known about these faults, the main drift usually was driven well through the fault zone, then short horizontal diamond-drill holes were drilled to the right and left from the drift face to pick up the faulted segment of the vein. A branch drift then was started from a point back of the fault and driven diagonally across the fault zone to the vein segment, then continued along the vein as before. Three diamond-drill holes also were drilled downward from the 500-foot level to hit the vein about at the 625-foot level (see fig. 4). As much dead work would have been necessary in order to drill from the hanging-wall side of the vein, these holes were drilled at fairly flat angles from the footwall side-two from old workings and one from a new drift.

METHODS OF SAMPLING AND ESTIMATION OF TONNAGES AND VALUES

All drifts are sampled at 5-foot intervals as they are being driven along the vein. The assay values of these samples then are plotted on the mine-level map, and stopes are started accordingly.

After stopes have been started, each car of ore from a stope is grab-sampled. These samples are composited to correspond to each railroad car of ore shipped, and it has been found that this composite sample usually compares very favorably with the smelter's analyses of the car of ore.

Stopes are "chip"-sampled at intervals, especially when visual inspection indicates any change.

Ore reserves are estimated as "ore blocked out" (measurable), "probable" (indicated), and "possible" (inferred). Where ore has been outlined by drifts, raises, and stopes it is called "positive ore" or "ore blocked out", where it has been partly delimited it is called "probable ore", and where there is good reason to think that ore exists it is called "possible ore."

In computing ore reserves, the vein is assumed to average 5 feet in width. Fourteen cubic feet a ton is used as a tonnage factor for the siliceous ore.

DEVELOPMENT METHODS

Shafts

The mine is opened by a vertical, 3-compartment, timbered shaft from the surface to 792 feet. This shaft, called the Cosden shaft by Lasky[7], was sunk to this depth in 1930 and 1931, when the Alamo Copper Co. operated the property. The shaft is completely timbered with 8- by 8-inch pine timbers. The compartments are 6 feet, center-to-center. Shaft sets were placed on 5-foot 8-inch centers in the upper part of the shaft and on 6-foot centers below. Walls are tightly lagged with 2-inch boards.

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[7] Lasky, Samuel G., Geology and Ore Deposits of the Lordsburg Mining District, New Mexico. U. S. Geol. Surv. Bull. 885, 1938, pp. 53-54 and plate 22.

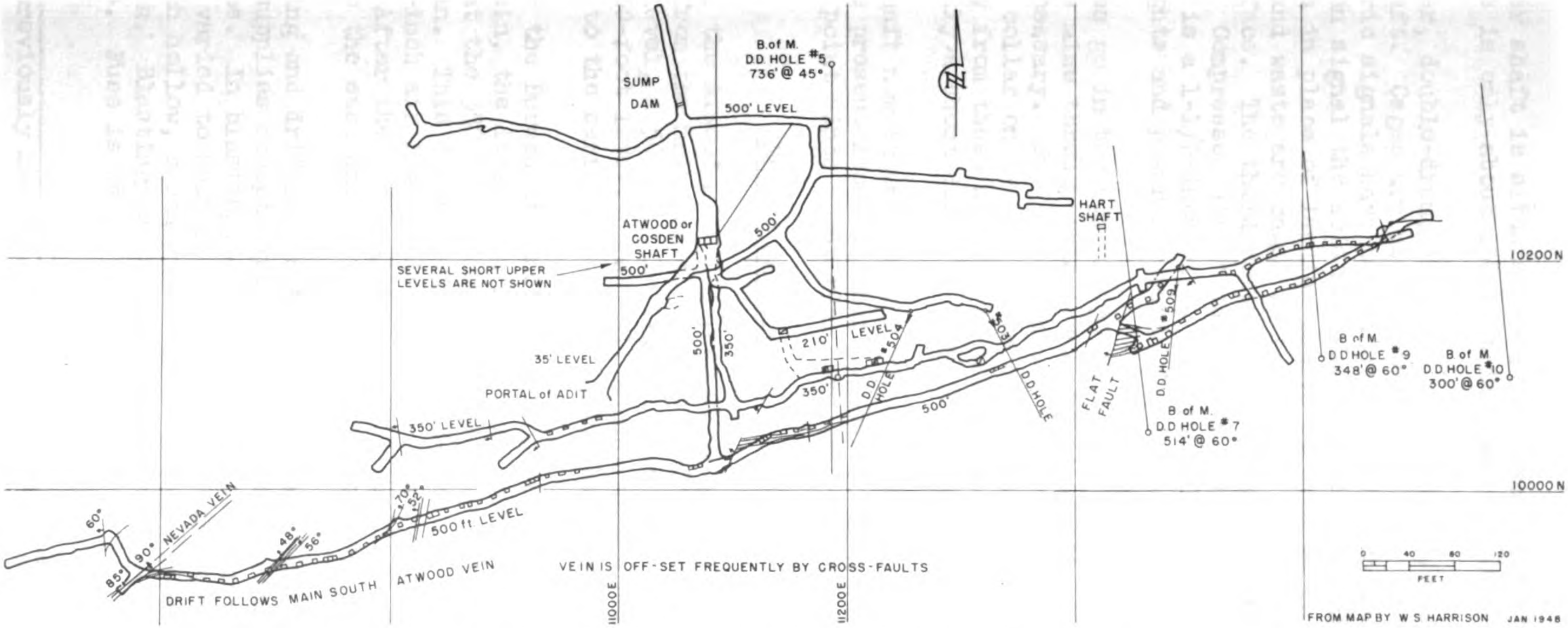

Figure 4. - Composite map of Atwood mine workings.

A second, older shaft is situated about 200 feet east of the main shaft, but this second one is only about 150 feet deep and is not used.

A 50-horsepower, double-drum, electric hoist with 7/8-inch steel cable serves the main shaft. Cages are used instead of skips, the two cages being in balance. Electric signals have been installed at each working level so that the cageman can signal the hoistman when lowering or raising the cage. Chain dogs are used in place of landing chairs at each working level to hold cages, as all ore and waste are caged in 1-ton cars to the adit level, thence trammed to the surface. The third compartment is used for manway, pipes, and an electric cable. Compressed air is taken down the shaft in a 4-inch pipe, and the water line is a 1-1/2-inch pipe. An armored electric cable carries electricity for lights and power for pumps and fans.

As all supplies go in through the 35-foot adit level, and all ore and waste come from the mine through this level, no elaborate headframe at the shaft collar is necessary. Two 4-foot sheave wheels are set immediately above the concrete shaft collar on 8-inch I-beam sets, the hoisting cables going nearly horizontally from these sheaves to the double-drum hoist. The hoist is in a small house only a short distance from the shaft.

As the main shaft now extends to the 792-foot point, no shaft work will be necessary by the present lessee. Shaft timbers, which have been under water below the 400-foot point since about 1931, are well-preserved.

Drifts and Crosscuts

Prior to 1943, the Atwood mine had been developed by an adit level at the 35-foot point from the main shaft, a short 75-foot level, a 150-foot level, a 210-foot level, a 500-foot level, and a short crosscut northward from the shaft on the 750-foot level.[8] A small amount of ore had been mined from the 210-foot level to the surface, but no stoping had been done below that point.

In 1943, after the Bureau of Mines had discovered the new ore shoot in the South Atwood vein, the lessee, C. H. McIntosh, cut a station on the south side of the shaft at the 350-foot point, then drove a 143-foot crosscut about S. 5° E. to the vein. This crosscut was 8- by 8-feet in cross section and carried track, a 3-inch air line, a 1-inch water line, and a cable for electric lights and power. After the crosscut encountered the South Atwood vein, drifts were driven both to the east and to the west along the vein (see fig. 4).

All crosscutting and drifting is done on contract, the lessee furnishing all equipment and supplies except explosives, and the contractor furnishing the labor and explosives. In blasting, an ordinary bottom draw-cut usually is used, although it may be varied to suit local conditions. Three-inch drifters are used with 1-1/8-inch hollow, round steel and detachable rock bits. Bit changes usually are 1/8-inch. Blasting is done with 45 percent gelatin dynamite and No. 6 blasting caps. Fuse is used exclusively.

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[8] Lasky, S. G., previously mentioned in footnote 7, plate 22.

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Drifts along the vein usually are carried 8 feet wide by 7 feet high where in ore and about 7 by 7 feet in waste. Timber sets are used only where chutes or raises are located and where stoping has been started immediately above the level. Ordinarily no timber is needed in drifts and crosscuts.

Mucking is done with a shovel loader loading directly into 1-ton end-dump mine cars. All track has an 18-inch gage with 12-pound rails on wooden ties. As previously mentioned, all waste and ore cars are caged to the 35-foot adit level, then trammed about 350 feet to the waste dump or ore bin. All underground and surface tramming is by hand.

Raises

Raises generally are carried 5 by 11 feet in cross sections, with a manway in the middle and a chute on each end. Raises are spaced on 90-foot centers. All are timbered with regular square-sets.

Chute raises are carried 5 by 5 feet in cross section from the back of the drift up into the stope. Chute raises are spaced on 15-foot centers.

All raising is done with stopers using 1-inch hollow, quarter-octagon steel with detachable rock bits. Forty-five percent gelatin dynamite is used with No. 6 blasting caps and fuse, the same as for drifting and crosscutting.

Ordinary chute pockets with stop-board gates are used in all raises. Some trouble is experienced in blasting large pieces of rock or ore in the chutes, necessitating frequent repairs. In developing the 625-foot level, the lessee plans to do away with chute pockets entirely and will load the muck from the bottom of the chute raises directly into cars with a shovel loader (see section on Stoping for further details).

MINING (STOPING) METHODS

All mining at the Atwood has been done by shrinkage-stoping methods. The vein is narrow, averaging about 5 feet, and the walls stand fairly well, except when fault-gouge occurs along the hanging wall. In places up to 1-1/2 feet of such gouge occurs along the hanging-wall fault and is drawn off with the ore. The hanging wall usually is well-defined, but the vein footwall is very indefinite. Minimum mining width is 3 feet.

On a level, when the vein is reached with a crosscut from the shaft, drifts are started along the vein to the east and the west. Where the vein is fairly wide and the ore is high-grade, a shrinkage stope is started from the back of the drift. In this case the drift is timbered, then heavy lagging is placed on top of the drift sets, chute pockets are put in on 15-foot centers, and the stope is carried on up. However, if the vein is low-grade or of average grade, chute raises are driven up 15 or 20 feet on 15-foot centers; then these raises are connected, leaving small level pillars between the chute raises above the drift. Manway raises are driven upward on 90-foot centers.

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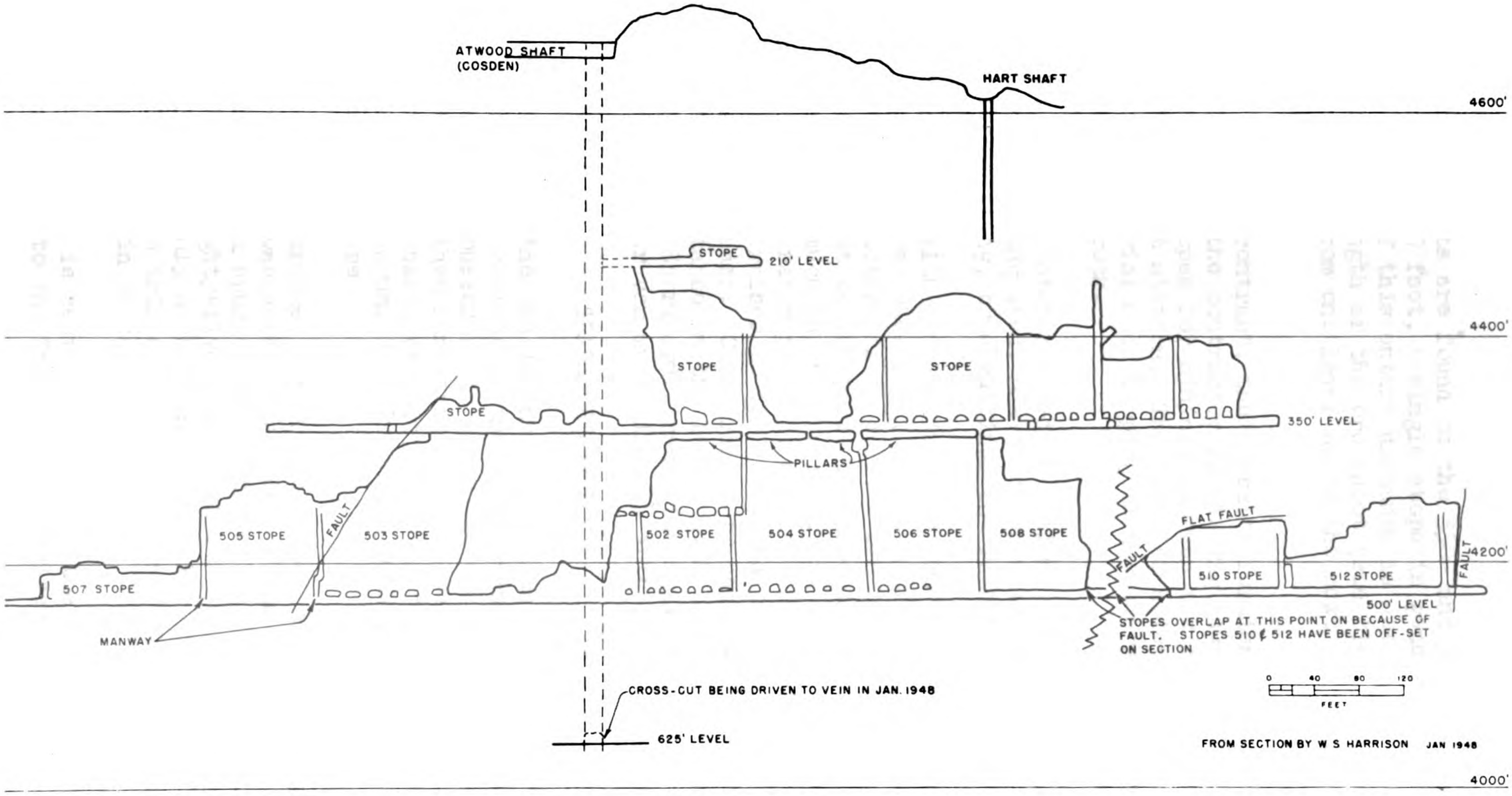

FROM SECTION BY W S HARRISON JAN 1948

Figure 5. - Longitudinal section along Atwood vein, looking northerly.

As numberous cross faults are found on the 350- and 500-foot levels that offset the vein as much as 35 feet, a single stope is generally from one of these faults to the next. If this entire distance is not in ore, the stope length is governed by the length of the ore shoot (see fig. 5 for section along vein). Stopes are carried from one level up to the next or to the top of the ore shoot.

All stoping is done on contract, the operator furnishing all equipment and supplies except explosives, the contractor furnishing the labor and explosives. The operator prepares the stopes for mining, whereas the contractor mines and delivers the ore to the shaft station. The operator hoists and dumps the ore at the surface. Close supervision of stoping is necessary in order to avoid diluting the ore with waste rock.

All stoping is done with stopers, 1-inch hollow, quarter-octagon steel with detachable rock bits being used. Gelatin dynamite with caps and fuse is used, the same as for drifting, crosscutting, and raising.

Stopes are carried up, with no blasting chambers above the chute pockets, for breaking up large boulders; therefore, blasting of such pieces must be done in the chutes. As the contractor has to deliver ore to the shaft station, he is rushed for time and can not be too particular about blasting in the chutes; this procedure necessitates much chute repairing. In order to eliminate the cost of chute repair, the operator plans to develop the 625-foot level so that ore will drop down the chute raises to the level and then will be loaded directly into cars with the shovel loader. Chute raises probably will be off-set into the footwall for a short distance on the level, with the side of the drift lagged to keep muck off the track. Short spur tracks then will be extended from the main track, so that the loader can muck directly into cars.

TRANSPORTATION

As has been mentioned, the ore in the Atwood mine is pulled from the chutes on the working levels by the contractor and hand-trammed to the shaft station, sometimes a distance of a thousand feet. From the shaft station, the cars are caged to the 35-foot level, then hand-trammed for about 350 feet, and dumped into the mine ore bin, which has a capacity of about 60 tons. Hoisting is done with a 50-horsepower, double-drum, electric hoist with 7/8-inch round steel cable with two cages in balance.

At the ore bin on the surface, the ore is dumped onto 2-inch grizzlies, where it is hand-sorted and waste rock discarded. From the ore bin the ore is hauled by truck to a railroad spur of the Southern Pacific Railroad that runs from Lordsburg to the old Eighty-five mine, a short distance southwest of the Atwood. This spur line is only a short distance below the mine. Trucks dump directly into gondola cars on this spur track from an earthen ramp. The truck haul is only 300 feet from bin to car.

From this point the ore is sent by railroad either to the International smelter at Miami, Ariz., or to the Phelps Dodge smelter at Douglas, Ariz.

VENTILATION

Ventilation in the Atwood mine is natural, except in dead ends, where small air blowers with canvas tubing are used. Usually, air comes down the main shaft to the levels, goes in through the levels to the stopes, and then back to the surface through the stopes. The recent stopes connect on the upper mine levels with old stopes and raises to the surface; therefore, good ventilation always is maintained.

DRAINAGE

Water usually stands at the 400-foot point in the shaft when no pumping is being done. The operator now has lowered the water to a point below the 625-foot level. A small electrically powered centrifugal pump on that level pumps to a sump on the 500-foot level, then a larger 2-stage centrifugal pump raises the water from the sump to the 35-foot adit level, where it flows out to the surface. The sump on the 500-foot level was made by building a concrete dam across a dead-end crosscut a short distance north of the shaft. Both pumps are automatically controlled by float valves in the shaft and sump. An average of 110 gallons a minute is pumped during 24 hours.

SAFETY MEASURES

Since all mining and development work at the Atwood is done by contract, safety is stressed very strongly. First-aid kits are kept on each working level in the mine as well as at a central place on the surface.

Approved cages have been installed in the shaft, and approved electric signals are at each working level for signaling the hoistman. Two escape manways are provided - one in the main shaft from the surface to the 625-foot level and the other from the 500-foot level to the surface through the stopes. To date, no connection has been made between the 625- and 500-foot levels other than through the main shaft, as the crosscut has just recently been started southward from the shaft to the South Atwood vein on the 625-foot level.

A good change house has been provided for the men, where hot and cold showers, toilet facilities, etc., are available. The operator, C. H. McIntosh, also operates a free bus from Lordsburg to the mine for the benefit of the employees.

ORGANIZATION

C. H. McIntosh leases the Atwood mine from the owners, J. L. Augustine of Lordsburg, N. Mex., and Rebecca L. Morningstar of Bemus Point, N. Y. William S. Harrison, mining engineer, supervises all work at the mine for the operator. O. H. Turrentine is mine foreman. Shift bosses and all mine labor, as well as the mine contractors, are under his direct supervision. A master mechanic oversees all mechanical equipment and repair work, and an accountant keeps all costs and time records.

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WAGE SCALE

The wage scale, as paid late in 1947, at the mine is shown below. This scale is the same as that of the Banner Mining Co., the largest operator in the Lordsburg district.

	Per hour
Mechanics	$1.25
Blacksmith	1.25
Hoistmen	1.05
Bit sharpener	1.02
Miners	1.02
Timbermen	1.02
Pipemen	1.02
Ore sorters	0.89
Top landers	0.89
Trammers	0.89
Timberman's helper	0.89
Drill helper (chuck tender)	0.89
Pipeman's helper	0.89
Mechanic's helper	0.89
Common labor	0.89

COSTS

Development

All development work is done on contract. The main crosscut from the shaft to the vein is contracted, as are the drifts along the vein. The contractor drills and blasts the crosscut or drift, then loads the muck into 1-ton cars with a shovel loader and hand-trams these cars to the shaft station. The operator takes the cars of muck at the shaft, cages them to the adit level, then hand-trams them out to the dump. In 1947, the contract price for driving the crosscuts from shaft to vein (8 by 8 feet, cross section) was $13 a foot. Contract price for driving the drifts along the vein was $10 a foot. As mentioned before, the operator furnishes all equipment and supplies, except explosives, which the contractor is required to buy. The contractor lays track, water line, and air line along crosscuts and drifts and also cuts a ditch along the track where necessary.

Mining

In stoping, the operator prepares the stopes for mining, then a contractor mines the ore. The operator puts in chutes, manways, etc. The contractor raises the manways as the stope is driven upward, keeping a manway at each end of the stope. He also installs water and air lines in raises, drills and blasts the ore, then draws it off at the level, and hand-trams it to the shaft station. Contract price for stoping in 1947 was $2.20 a ton of ore.

Haulage of ore from the mine ore bin to the railroad cars also is contracted. This cost is $10 for a 60-ton car (the truck haul is 300 feet).

During 1947, the average total cost for delivering ore to railroad cars was $7.50 a ton, including all development costs.